SP-E1.4 Thermalito Complex Temperature Model Development

October 25, 2002

1.0 Introduction/Background

Water is released from Oroville Reservoir through Hyatt Powerhouse. A portion of this water is then diverted into the Thermalito Forebay/Afterbay complex and used for power generation purposes before being diverted for agricultural use or returned to the Feather River. While in the Forebay/Afterbay complex the water typically warms due to the large shallow nature of the reservoirs. The agricultural diversions, a large portion of which goes to rice growers require specific temperatures for proper germination and growth. The cold-water fishery in the Feather River requires lower temperatures to provide appropriate habitat for the fish. These conflicting temperature requirements make understanding the warming that happens in the Forebay/Afterbay complex critical in performing impact analysis.

2.0 Study Objective

The goal of this study is to develop a model to estimate the warming between the Oroville Reservoir release temperatures and the Afterbay release temperatures using benchmark simulations. The main concerns are the temperatures released from the east side of Afterbay into the Feather River and the west side of the Afterbay to be used for farming.

3.0 Relationship to Relicensing /Need for the Study

In order for the Oroville facilities to obtain a new license the Federal Energy Regulatory Commission (FERC) requires water quality certification from the State Water Quality Control Board (SWRCB). The certification requires that SWRCB determine that the project complies with the temperature requirements of the Central Valley Water Resource Control Board (CVWRCB) Basin Plan (SPW1, 01). This study will enhance the information developed for FERC.

Diversions of water for agriculture, particularly rice fields, in-stream fisheries, and the hatchery all have specific, often conflicting, temperature requirements. Rice farmers require warmer temperatures to apply to their rice fields, while fisheries require cold temperatures. Evaluation of the impacts of operational alternatives and providing input for further simulation modeling require information on the warming that occurs in the Forebay/Afterbay Complex.

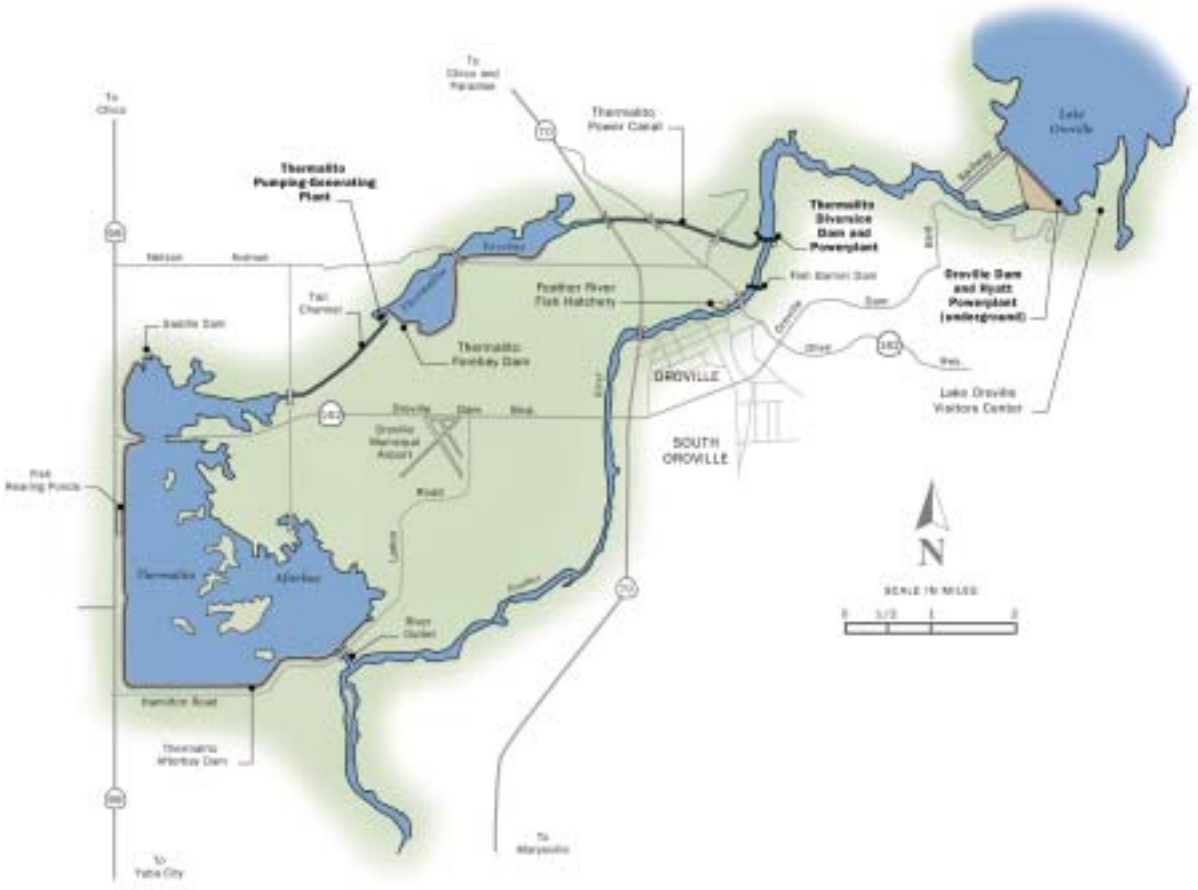
Engineering and Operations Issues Addressed

- E4—evaluate environmental and economic aspects of different flow regimes of Oroville Facilities operations. Factors to be considered include timing, magnitude and duration of flows, pump-back scheduling and maintenance scheduling, and hatchery operations.
- E6—effect of ramping rates on downstream facilities, power generation, water supply, water temperatures, and fish.

- E12—evaluate operational and engineering alternatives including selective withdrawal from Lake Oroville, Thermalito Afterbay, the hatchery, and the low flow section to meet various downstream temperature requirements.
- E14—evaluate operational alternatives that balance and maintain acceptable water quality standards including those for MTBE under all operational plans and conditions.

4.0 Study Area

The study area includes the diversion pool downstream of the Oroville Dam, the Thermalito Forebay and the Thermalito Afterbay. Geographic scope may be refined as additional information is developed and needs are identified through collaboration with other Work Groups.



5.0 General Approach

The Thermalito Forebay/Afterbay Complex is hydraulically and thermodynamically diverse. Water is released from the Oroville Reservoir and diverted into the Thermalito Forebay. The water is then released into the Thermalito Afterbay to generate power. Some of the water within the Afterbay may be pumped back to the

Forebay and possibly back into the Oroville Reservoir to be reused for power generation. Each portion of the Thermalito Forebay/Afterbay Complex has different rates at which temperatures can change. Due to the hydraulic and thermodynamic complexity of the Thermalito Forebay/Afterbay it would be extremely difficult to build a numerical model that simulates the system dynamics.

This study plan will attempt to develop an empirical relationship between Oroville Reservoir release temperatures and Afterbay diversion and Feather River release temperatures utilizing historical data. The model will be verified to accommodate different operating scenarios. Because of the projected use of the estimated warming that occurs it is preferable that the relationship slightly over estimate the warming over under estimation.

Task 1—Define Desired Outputs from the Model

As currently formulated the required products from this model include:

- Pumpback temperature
- Agricultural diversion temperature
- Afterbay outlet temperatures
- Diversion pool temperatures (?)

Additional desired outputs may be identified as the study plans from other work groups are completed and the process proceeds.

Task 2—Review Existing Models

There are no existing temperature models for the Thermalito System known of at this time.

Task 3—Review Existing Data

Types of data required include:

This task will collect all available historical data that could be useful in developing the empirical relationship. Existing data that may be useful includes:

- Physical characteristics
- Depth to Surface area relationships
- Storage/Volume data
- Meteorological data
- Operational data (inflows, diversions, release, temperatures, etc.)
- Climatic data (temperature, solar radiation, wind, etc.)

Existing data identified at this time is listed in Attachments A.

Task 4—Review Modeling Tools

Due to complexity of system will use and empirical approach to determine the relationship between Oroville Reservoir release temperatures and Afterbay release temperatures to the Feather River. A commercial statistical analysis software package such as SPLUS may be used.

Task 5—Select Appropriate Model or Modeling Tool

Based on the results of task 1 through 4 select the appropriate model/modeling tool to create the Thermalito Complex temperature model for this process. The workgroup has approved the use of an empirical, or statistical, approach to building this model.

Potential dependant variables include:

- Release to Feather River temperature
- Agricultural diversion temperature
- Pumpback temperature

Potential independent variables include:

- Oroville release temperature
- Climatic condition
- Flow rates

Task 6—Collect Field Data for Development/Calibration/Verification

Statistical models require specific data for development/calibration/verification purposes just as numeric models; however the specific data requirements are not known until the statistical analysis is performed. With numeric models the data requirements are defined by the modeling tool and system being modeled. This task will be performed as part of Task 7.

Task 7—Complete Model Development/Calibration/Verification

The actual model development will consist of statistical evaluation of the available data. The appropriate independent parameters and the format of the relationship will be developed and verified using the existing data. Additional data requirement may be identified to enhance the usefulness of the final relationship. The following steps will need to be performed for successful model development:

- Define system to be modeled and schematic to be used.
- Develop relationships between the dependant and independent variables assumed. This effort corresponds to the model selection, development, and calibration work in development of a numeric model.
- Collect additional field data if required.
- Complete model development/calibration.
- Verify completed model. The model will be verified to accommodate different operating scenarios.

Task 8—Integrate Completed Model into Model Development Scheme

Integration of the model into the model development scheme will require development of the transfer utilities defined in Study #E1. These transfer utilities will be used for three main purposes:

- Extract data from the central modeling database, modify this data as required for input to the Thermalito Complex temperature model.

- Extract data from the Thermalito Complex temperature model output files, perform any computation on them that may be required and store the results in the central modeling database
- Allow review of all data being transferred for quality control purposes

Task 9—Perform Benchmark Simulations

Perform the Thermalito Complex temperature modeling to provide the detailed benchmark simulations by performing the following actions:

- Get boundary conditions from central modeling database
- Use utility programs to create input based on the boundary conditions
- Perform the actual simulations
- Use utility programs to load data into central modeling database

The development will also be coordinated with study plans from other workgroups that will require evaluation of temperature impacts from Thermalito Complex operations.

6.0 Results and Products/Deliverables

Results

This study plan will result in a Thermalito Complex Temperature model and benchmark studies for use in the process.

Products/Deliverables

There will be two products of this study plan:

- A Thermalito Complex temperature model that focuses on the Thermalito Afterbay release temperature with no information about temperatures within the Thermalito Complex itself. This product will be fully integrated into the overall modeling scheme.
- Simulated Thermalito Complex temperature operations for the benchmark studies for use in other analysis.

7.0 Coordination and Implementation Strategy

Coordination with Other Resource Areas/Studies

This section to be developed.

Engineering and Operation Study Plans

- Study Plan #1—Model Development
- Study Plan #1b—Local Operations Model Development

- Study Plan #1c—Oroville Reservoir Temperature Model Development
- Study Plan #1e—Feather River Temperature Model Development
- Study Plan #2—Modeling Simulation

Issues, Concerns, Comments Tracking and/or Regulatory Compliance Requirements

In order for the Oroville facilities to obtain a new license the Federal Energy Regulatory Commission (FERC) requires water quality certification from the State Water Quality Control Board (SWRCB). The certification requires that SWRCB determine that the project complies with the temperature requirements of the Central Valley Water Resource Control Board (CVWRCB) Basin Plan (SPW1, 01). This study will enhance the information developed for FERC.

8.0 Study Schedule

This section to be developed.

Attachment A
State Water Project Operation Data

	Location	Data Description	Data Description 2	Units	Data Type	Start Date	End Date	Data Source
1	Lake Oroville	Water Surface Elevation		Feet	Daily	Jan-90	Present	SWP
2	Lake Oroville	Storage		Acre-Feet	Daily	Jan-90	Present	SWP
3	Lake Oroville	Storage Change		Acre-Feet	Daily	Jan-90	Present	SWP
4	Lake Oroville	Outflow	Hyatt Powerplant	Acre-Feet	Daily	Jan-90	Present	SWP
5	Lake Oroville	Outflow	Palermo Canal	Acre-Feet	Daily	Jan-90	Present	SWP
6	Lake Oroville	Outflow	Evaporation	Acre-Feet	Daily	Jan-90	Present	SWP
7	Lake Oroville	Outflow	Spill	Acre-Feet	Daily	Jan-90	Present	SWP
8	Lake Oroville	Outflow	Total Outflow	Acre-Feet	Daily	Jan-90	Present	SWP
9	Lake Oroville	Inflow	Hyatt Powerplant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
10	Lake Oroville	Inflow	Computed Inflow	Acre-Feet	Daily	Jan-90	Present	SWP
11	Thermalito Forebay	Storage		Acre-Feet	Daily	Jan-90	Present	SWP
12	Thermalito Forebay	Storage Change		Acre-Feet	Daily	Jan-90	Present	SWP
13	Thermalito Forebay	Inflow	Lake Oroville Releases	Acre-Feet	Daily	Jan-90	Present	SWP
14	Thermalito Forebay	Inflow	Kelly Ridge Generation	Acre-Feet	Daily	Jan-90	Present	SWP
15	Thermalito Forebay	Inflow	Thermalito Pumping-Generation Plant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
16	Thermalito Forebay	Outflow	Thermalito Pumping-Generation Plant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
17	Thermalito Forebay	Outflow	Butte County	Acre-Feet	Daily	Jan-90	Present	SWP
18	Thermalito Forebay	Outflow	Thermalito Irrigation District	Acre-Feet	Daily	Jan-90	Present	SWP
19	Thermalito Forebay	Outflow	Releases to River	Acre-Feet	Daily	Jan-90	Present	SWP
20	Thermalito Forebay	Outflow	Hyatt Powerplant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
21	Thermalito Forebay	Losses and Gains		Acre-Feet	Daily	Jan-90	Present	SWP
22	Thermalito Afterbay	Water Surface Elevation		Feet	Daily	Jan-90	Present	SWP
23	Thermalito Afterbay	Storage		Acre-Feet	Daily	Jan-90	Present	SWP
24	Thermalito Afterbay	Storage Change		Acre-Feet	Daily	Jan-90	Present	SWP
25	Thermalito Afterbay	Inflow	Thermalito Pumping-Generation Plant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
26	Thermalito Afterbay	Outflow	Sutter Butte Canal	Acre-Feet	Daily	Jan-90	Present	SWP
27	Thermalito Afterbay	Outflow	Western Canal Lateral	Acre-Feet	Daily	Jan-90	Present	SWP
28	Thermalito Afterbay	Outflow	Richvale Canal	Acre-Feet	Daily	Jan-90	Present	SWP
29	Thermalito Afterbay	Outflow	Western Canal	Acre-Feet	Daily	Jan-90	Present	SWP
30	Thermalito Afterbay	Outflow	Afterbay River Outlet	Acre-Feet	Daily	Jan-90	Present	SWP

	Location	Data Description	Data Description 2	Units	Data Type	Start Date	End Date	Data Source
31	Thermalito Afterbay	Outflow	Thermalito Pumping-Generation Plant Pumpback	Acre-Feet	Daily	Jan-90	Present	SWP
32	Thermalito Afterbay	Losses and Gains		Acre-Feet	Daily	Jan-90	Present	SWP
33	Thermalito Afterbay	Total Releases to River		Acre-Feet	Daily	Jan-90	Present	SWP
34	Oroville-Thermalito Complex	Mean Daily Water Temperature	Thermalito Afterbay Outlet	Fahrenheit	Daily	Jan-90	Present	SWP
35	Oroville-Thermalito Complex	Mean Daily Water Temperature	Fish Hatchery	Fahrenheit	Daily	Jan-90	Present	SWP
36	Oroville-Thermalito Complex	Lake Oroville Temperature Profile	Graph of Temp by Elevation	Fahrenheit/Feet	Daily	Jan-90	Present	SWP
37	Oroville and Delta Field Divisions Energy Data	Oroville-Thermalito Complex	Generation	KWH	Daily	Jan-90	Present	SWP
38	Oroville and Delta Field Divisions Energy Data	Oroville-Thermalito Complex	Load	KWH	Daily	Jan-90	Present	SWP
39	Oroville and Delta Field Divisions Energy Data	Baker Slough Pumping Plant Load		KWH	Daily	Jan-90	Present	SWP
40	Oroville and Delta Field Divisions Energy Data	Cordelia Pumping Plant Load		KWH	Daily	Jan-90	Present	SWP
41	Oroville and Delta Field Divisions Energy Data	Banks Pumping Plant	Total Load	KWH	Daily	Jan-90	Present	SWP
42	Oroville and Delta Field Divisions Energy Data		SWP Load	KWH	Daily	Jan-90	Present	SWP
43	Oroville and Delta Field Divisions Energy Data	South Bay Pumping Plant Load		KWH	Daily	Jan-90	Present	SWP
44	Oroville and Delta Field Divisions Energy Data	Del Valle Pumping Plant Load		KWH	Daily	Jan-90	Present	SWP